Executive Summary Content

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Purpose

The purpose of this report is to summarize and interpret water quality data collected near or in the Sacramento-San Joaquin Delta (the Delta) from August 1998 through September 2001. The Municipal Water Quality Investigations (MWQI) program of the California Department of Water Resources (DWR) provides Delta source water quality information to the State Water Contractors through continuous monitoring at selected sites. Among the many State and local agencies that are monitoring the Delta and its tributaries, MWQI conducts the only monitoring program whose primary mission is to investigate quality of source waters in the Delta. Since 1983 MWQI has been conducting comprehensive and systematic source water monitoring at export and diversion stations within the Delta, various sites along Delta tributaries, and urban and agricultural drainage canals within or near the Delta. MWQI regularly prepares annual or multi-year data summary reports. The previous annual report summarized data collected through July 1998.

Background

Rivers and channels of the Delta are a major source of drinking water for more than 22 million people in California. Delta waters originate mostly as precipitation in the Sierra, the Cascade Range, and in the watersheds within the Sacramento and San Joaquin valleys. In these areas, precipitation is unevenly distributed throughout the year with most of the annual precipitation occurring from November through April (wet months). Water from the wet months must be stored outside the Delta and transported through the Delta before it is exported or diverted. The quality of the water often deteriorates as water traverses the complex Delta tributaries and channels, especially during dry and critical water years when annual precipitation is low.

In addition to uneven distribution and limited amounts of rainfall, other factors and sources can degrade Delta water quality: infiltration of seawater with high salinity and bromides, releases of organic carbon from peat soils of the Delta islands, phytoplankton growth and decay in rivers and channels, agricultural practices and drainage discharges, urban runoff and discharges, and recirculation of Delta waters through the San Joaquin Valley.

The Delta is highly complex and variable, and water operations in the Delta are constrained by competing interests. Accordingly, it will not be feasible to alter the processes and sources that degrade Delta waters in the near term. Frequent monitoring is necessary to identify water quality constraints and spatial and seasonal patterns to assist Delta water users to treat and manage their source waters. Long-term monitoring data are essential to the development, calibration, and validation of predictive computer models. These models may subsequently be used for long-term resource and facilities planning and project operations.

Scope of Report

Presented are data from 14 MWQI stations. Five of these stations monitor water quality from the San Joaquin River (SJR), the Sacramento River, and the American River as they flow into the Delta. Three of these 5 stations are on the American and Sacramento rivers at or near the north end of the Delta—American River at E. A. Fairbairn Water Treatment Plant (WTP), Sacramento River at West Sacramento WTP Intake, and Sacramento River at Hood. The E. A. Fairbairn WTP represents water quality of the American River, which is a major tributary of the Sacramento River. West Sacramento WTP Intake represents water quality of the Sacramento River before mixing with water of the American River, and the Sacramento River at Hood reflects the quality of water from the Sacramento River shortly after it enters the Delta. Two of the 5 stations are along the SJR—SJR near Vernalis and SJR at Highway 4 in the southern part of the Delta. The Vernalis station represents SJR water quality as it enters the Delta. The Highway 4 station reflects urban influence on water quality from the city of Stockton.

Six of the 14 stations are within the Delta or at diversions of the Delta. Two of the 6 stations—the Old River at Station 9 and Old River at Bacon Island—are Delta channel stations representing quality of mixed waters primarily from the SJR and Sacramento River. Water is being diverted near the Old River at Station 9 at a pumping station of the Contra Costa Water District (CCWD). Three of the 6 stations—Banks Pumping Plant, Delta-Mendota Canal (DMC) at McCabe Road, and Contra Costa Pumping Plant No. 1—are diversion stations that reflect source water quality before waters are diverted from the Delta. The Sacramento River at Mallard Island is a station at the western end of the Delta, which is most susceptible to seawater influence due to its proximity to the San Francisco and Suisun bays. CCWD also has an intake at Mallard Slough, which is near Mallard Island. CCWD only operates this intake during high Delta outflow conditions when chloride concentration is below its maximum contaminant level (MCL).

MWQI also monitors 3 drainage stations: 2 agricultural drainage stations within central Delta—Bacon Island Pumping Plant and Twitchell Island Pumping Plant—and an urban drainage site—Natomas East Main Drainage Canal (NEMDC). These stations represent water quality at agricultural and urban drainages.

Limited salinity data from DWR’s San Joaquin District and the U.S. Bureau of Reclamation (USBR) are presented in the discussions of water quality in the upper SJR south of Vernalis. Data from the USBR station at Greenes Landing on Sacramento River are also included. These data help identify sources of salinity loads.

Water quality constituents in Delta source waters are presented according to current regulatory priorities with organic carbon, bromide, and salinity addressed in individual chapters. For each constituent at each station, descriptive plots in the form of temporal graphs describe general seasonal patterns. Summary statistics that include range, median, and percentiles show general data characteristics. The Loess Smooth Procedure is often performed to show seasonality and constituent sources such as the effects of rice drainage and agricultural activity on water quality. No data on bacteria or pathogens are included in this report.

Summary of Findings

Organic Carbon

Organic carbon in the Delta and its tributaries differed both seasonally and spatially (Figure A). Median total organic carbon (TOC) for the American and Sacramento River stations north of the Delta was generally less than 2 mg/L, whereas median TOC for the 2 SJR stations ranged from 3.1 to 3.5 mg/L. The median TOC at Mallard Island was 2.5 mg/L, reflecting multiple sources of water at this station. The 2 Delta channel stations—Old River at Station 9 and Old River at Bacon Island—and the 3 diversion stations—Banks Pumping Plant, DMC, and Contra Costa Pumping Plant #1—receive water from both the SJR and the Sacramento River. Despite dilutional effects of water from the Sacramento River, median TOC for these stations was similar to that of the SJR stations, suggesting that additional sources of organic carbon exist. Agricultural drainage and in-channel phytoplankton growth and decay are sources of organic carbon.

Figure A Total organic carbon: Range, median (mg/L) (map)

Seasonal patterns of organic carbon differed between tributary stations and channels. At each tributary station, organic carbon was generally significantly higher during the wet months when there was rain in the watershed than during the dry months. Seasonal patterns at the 2 Delta channel stations and at the 3 diversion stations differed from those at SJR and the Sacramento River stations, further indicating additional organic carbon sources.

The data suggest 4 major organic carbon sources:

1) Runoff from watersheds in the Sacramento and San Joaquin valleys
2) Urban runoff and discharges
3) Agricultural drainage
4) River and channel phytoplankton production

TOC in the Delta rivers, channels, and diversion stations was high. Given the ranges of alkalinity of most Delta source waters, the Disinfectants/Disinfection Byproducts (D/DBP) Rule would require removal of approximately 25% to 35% of TOC before disinfectants may be added to water taken from the Delta diversion stations and used as a source for drinking water.

Bromide

The data suggest that bromide in Delta source waters came from seawater. Bromide concentrations were higher at stations closer to seawater influence (Figure B). The stations at the north end of the Delta are not influenced by seawater; therefore, bromide concentrations were very low.

Figure B Bromide: Range, median (mg/L) (map)

General seasonal patterns of bromide differed from those of organic carbon. Despite some variations, organic carbon generally increased during the wet months and decreased during the dry months. Bromide levels could increase both during the wet months and during the dry months due to loads from agricultural lands. In general, bromide levels appear to have been inversely related to the amount of annual precipitation. Unlike organic carbon, bromide loads do not increase with high precipitation from the Sacramento Valley; instead, the precipitation dilutes bromide concentrations. Precipitation in the San Joaquin Valley may increase loads because rain washes soil bromide to the SJR.

In addition to these general trends, the data also suggest the following:

- Urban discharges and runoff from the watersheds in the Sacramento Valley were not a significant source of bromide in Delta waters because bromide concentrations in waters of the American and Sacramento rivers and the NEMDC were low.
- Seawater influence, either directly or indirectly, increases bromide levels in waters of Delta channels, diversion stations, and the SJR. Bromide at the 3 diversion stations was high. The Contra Costa Pumping Plant #1 had the highest bromide because it is closer to Mallard Island, which is the most susceptible to seawater influence among all the stations included in this report.
- Indirect seawater influence—irrigation water, old marine deposits, and shallow groundwater in the San Joaquin Valley—increases bromide concentrations in the SJR. For years, agricultural lands in the San Joaquin Valley have been irrigated with DMC water, which contains considerable bromide. Bromide in irrigation water is concentrated and discharged to agricultural drainage canals and recirculated within Delta channels. Soils in some areas were developed from old marine deposits with high levels of bromide that may be concentrated on the soil surface and washed into the river during wet months of low to moderate rainfall. In some areas, shallow groundwater carries high levels of bromide and moves into the SJR through seepage. Therefore, bromide levels in the SJR and Delta channels were high.
- High Delta outflows lower bromide levels at seawater-affected stations such as Mallard Island and nearby stations. Freshwater outflow not only keeps seawater from entering the Delta, it also dilutes bromide already present in the waters. Therefore, bromide levels were lower during wet years when outflows were greater and significantly higher during dry or critical water years when Delta outflows were less.
- Bromide levels at western Delta stations could be higher during the wet months when Delta outflows are reduced because reservoirs are releasing less water. Reduced reservoir releases are insufficient to hold back seawater, which results in higher bromide concentrations.

Salinity

The data suggest that seawater influence was the primary source of salinity throughout the western Delta as indicated by the high median electrical conductivity (EC) and the wide EC range at Mallard Island (Figure C). Salinity at the diversion and Delta channel stations generally varied with their distance from the Mallard Island station where seawater influence was the greatest. An exception is the DMC where the SJR influence may play a major role (Figure C).

Figure C Electrical conductivity: Range, median (µs/cm) (map)

Salinity of SJR water was significantly higher than waters from the American and Sacramento rivers, partially due to discharge of recirculated irrigation water from the DMC, which is seawater-influenced.

Salinity was significantly lower at Delta channel and diversion stations than at the SJR due to the dilutional effects of water from the Sacramento River. This dilutional effect was not observed with TOC, which implies that some organic carbon was produced within the Delta.

In addition to seawater intrusion, salinity in Delta waters are affected by sources that include watershed runoff, urban discharges, and agricultural drainage. Salinity loads from the watersheds were significant during the wet months, especially after each of the first few significant rain events.

Other Constituents

MWQI monitored constituents that are known either to have adverse human health effects or to degrade taste, odor, or appearance of finished drinking water. Monitoring was primarily at the diversion stations. Of all the constituents monitored, none was found at concentrations above the State or federal MCLs (Table A). The highest concentrations of lead, selenium, chromium, arsenic, iron, manganese, copper, and zinc never exceeded the objectives specified in “Article 19 Water Quality” of the *Standard Provisions for Water Supply Contract*.

Table A Inorganic and miscellaneous constituents

Recommendations

- Increase monitoring frequency at some stations during the wet months from monthly to weekly (or biweekly at key stations) for constituents such as organic carbon, bromide, turbidity, and EC. Since November 2001, MWQI has conducted weekly sampling during the wet months at some sites.

- Replace the insufficient monthly EC and bromide data from Mallard Island with real-time data. Both constituents vary greatly within a day, and values vary depending on when samples are taken. Therefore, monthly data are limited in explaining temporal patterns of EC and bromide at this and nearby sites. MWQI recommends continuation of the monthly grab sampling at Mallard Island for constituents other than EC. An arrangement should be made with the Interagency Ecological Program of DWR to share real-time EC data with MWQI. In addition, real-time bromide monitoring capability should be explored. Commercially available bromide electrodes suffer from low sensitivity. However, real-time bromide concentrations may be reliably estimated from chloride concentrations. Sensitive electrodes for measuring the chloride ion are available.

- Discontinue monitoring for methyl tertiary-butyl ether (MTBE). During the reporting period, 650 samples were analyzed and about 25% of the samples had MTBE at or slightly above its reporting limit of 0.001 mg/L. Concentration ranged from 0.001 to 0.005 mg/L, with a median of 0.002 mg/L. Most positive finds are in waters of the Sacramento River. Considering the long distance from the Sacramento River to the diversion stations, the volatility of MTBE under Delta conditions and the disturbances of water treatment processes, and the phasing out of MTBE as a fuel additive, further monitoring of MTBE in Delta source waters is not necessary.

- Resume nutrient monitoring and study the effects of nutrients on in-channel production of organic carbon and the interrelationships between nutrient fluxes and organic carbon levels, especially during the summer months.

- Analyze grab sample TOC using the wet oxidation method unless further research proves it to be inadequate. MWQI has been using the wet oxidation method for more than a decade. The method does not fluctuate as much as the combustion method. Like the combustion method, it measures a fraction of carbon present in a sample. Current studies of the 2 methods within DWR's Office of Water Quality may provide further clarification of this issue.

- Monitor the SJR near Salt and Mud Slough and its drainage sites to understand the seasonality and to establish some ranges. This section of the river appears to contribute organic carbon, salinity, and bromide to the Delta. The monitoring could be undertaken as a special project in collaboration with DWR's San Joaquin District and in coordination with monitoring efforts of the Grassland Bypass Project.

Table A Inorganic and miscellaneous constituents

Constituents	Findings	Regulation compliance
Constituents with adverse effects on human health		
Aluminum	Detected at or above reporting limit in 17 of 69 samples (25%) collected at 2 diversion stations; range: 0.01–0.08 mg/L; median: 0.04 mg/L	Never exceeded State or federal MCL of 0.2 mg/L
Antimony, cadmium, and lead	Never detected at or above reporting limits	Never exceeded federal primary MCL
Arsenic	Detected at or above reporting limit in all 69 samples; range: 0.001–to 0.003 mg/L; median: 0.002 mg/L	Never exceeded federal MCL of 0.01 mg/L
Barium	Of 59 samples collected at diversion stations, only one sample was found at the reporting limit of 0.05 mg/L	Never exceeded federal MCL of 2 mg/L or DHS MCL of 1 mg/L
Chromium (total)	Detected at or above reporting limit in 38 of 69 samples (55%); range: 0.003–0.009 mg/L; median: 0.006 mg/L	Never exceeded federal MCL of 0.1 mg/L or DHS MCL of 0.05 mg/L
Copper	Detected at or above reporting limit in all 69 samples collected at 2 diversion stations; range: 0.001–0.007 mg/L; median: 0.002 mg/L	Never exceeded State or federal MCL of 1.0 mg/L
Mercury	Of 58 samples, one sample was found at 0.0002 mg/L	Never exceeded federal MCL of 0.002 mg/L
Nickel	Detected at or above reporting limit in 40 of 41 samples (98%); range: 0.001–0.002; median: 0.001 mg/L	Never exceeded DHS MCL of 0.1 mg/L
Nitrate+Nitrite (as N)	Detected in all 29 samples at Banks; range: 0.13–1.20 mg/L, median: 0.51 mg/L	Never exceeded DHS MCL of 10 mg/L
Selenium	Detected at or above reporting limit in 16 of 54 samples (30%); range: 0.001–0.003 mg/L; median: 0.002	Never exceeded federal MCL of 0.05 mg/L
Constituents with adverse effects on taste, odor, or appearance		
Iron	Detected at or above reporting limit in 49 of 69 samples collected at 2 diversion stations (71%); range: 0.005–0.117 mg/L; median: 0.017 mg/L	Never exceeded federal MCL of 0.3 mg/L
Manganese	Detected at or above reporting limit in 39 of 69 samples collected at 2 diversion stations (57%); range: 0.005–0.032 mg/L, median: 0.12 mg/L	Never exceeded federal MCL of 0.05 mg/L
Silver	Never detected at or above reporting limit in any of the 69 samples collected at 2 diversions stations	Never exceeded federal MCL of 0.1 mg/L
Zinc	Never detected at or above reporting limit in any of the 69 samples collected at 2 diversions stations	Never exceeded federal MCL of 5 mg/L
MTBE	Of 650 samples collected, about 25% were at or above reporting limit of 0.001 mg/L; range: 0.001–0.005 mg/L; median: 0.002 mg/L	Never exceeded DHS enforceable primary drinking water MCL of 0.013 mg/L; never exceeded DHS enforceable secondary MCL of 0.005 mg/L

MCL = maximum contaminant level

Figure A Total organic carbon: Range, median (mg/L)

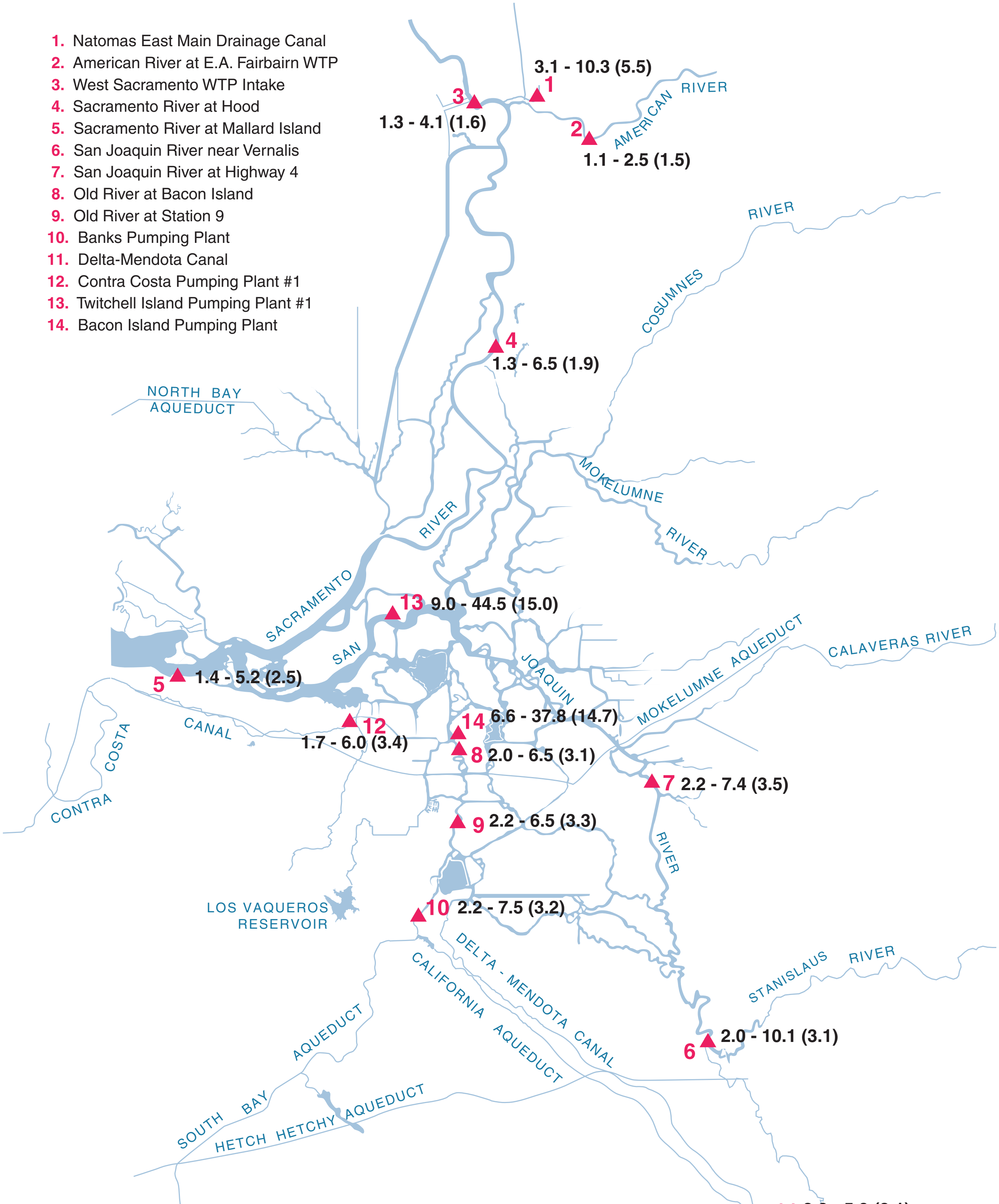

Figure B Bromide: Range, median (mg/L)

1. Natomas East Main Drainage Canal
2. American River at E.A. Fairbairn WTP
3. West Sacramento WTP Intake
4. Sacramento River at Hood
5. Sacramento River at Mallard Island
6. San Joaquin River near Vernalis
7. San Joaquin River at Highway 4
8. Old River at Bacon Island
9. Old River at Station 9
10. Banks Pumping Plant
11. Delta-Mendota Canal
12. Contra Costa Pumping Plant #1
13. Twitchell Island Pumping Plant #1
14. Bacon Island Pumping Plant

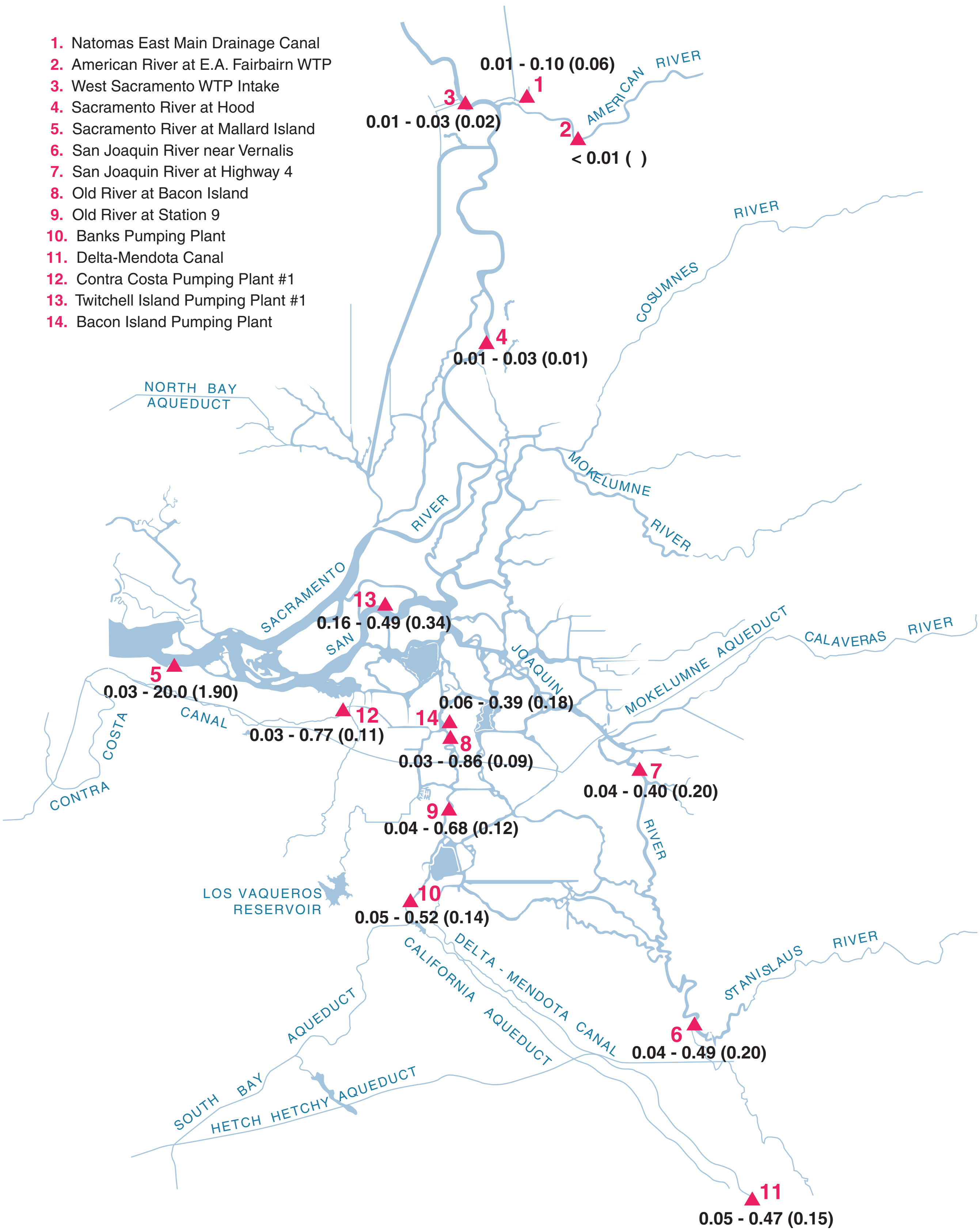

Figure C Electrical conductivity: Range, median (µS/cm)